(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 480 729 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication of patent specification: **01.03.95**

(51) Int. Cl.[6]: **A61K 9/50**, A61K 9/51, A61K 9/52, A61K 9/127, //A61K31/44

(21) Application number: **91309337.3**

(22) Date of filing: **10.10.91**

(54) Microencapsulation for controlled oral drug delivery system.

(30) Priority: **11.10.90 KR 9016120**
02.07.91 KR 912092

(43) Date of publication of application:
15.04.92 Bulletin 92/16

(45) Publication of the grant of the patent:
01.03.95 Bulletin 95/09

(84) Designated Contracting States:
DE FR GB IT NL

(56) References cited:
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EP 0 480 729 B1

Description

BACKGROUND OF THE INVENTION

(1) Field of the Invention

This invention relates to a microencapsulation for the preparation of controlled oral drug delivery system. In particular, it relates to a microencapsulation method of an oil droplet containing a drug for oral administration.

Especially, it relates to a microencapsulation method of a drug for oral administration using the biodegradable and bio-compatible material such as polysaccharide that have a metal chelating capacity for the purpose of minimizing the gastric upset or the damages on the stomach.

More especially, it relates to a microencapsulation method of oil containing drugs for oral administration using the biodegradable and biocompatible material such as polysaccharide for the purposes of minimizing the degradation of drug caused by hepatic first-pass metabolism by inducing lymphatic absorption of drug, and the degradation of drug in the strong acidic condition of gastric juice.

Recently, research groups have focused their studies on the desirable drug carrier system because the existing method for medicating drugs by oral administration or injection, have many problems on:-

1) the degradation of drug by hepatic first-pass metabolism;

2) the severe gastric upset or damages on the stomach by drug's activity;

3) the degradation of drug in the stomach by the strong acidic condition of gastric juice.

However, the existing methods for drug administration using oral route or injection, have been used because of their convenience to take medicine.

Although in principle the entire gastrointestinal tract is capable of drug absorption, the small intestine is the major site of absorption for drug.

A drug molecule, after diffusing through the mucosa of the intestine, is accessible to both the lymphatic and blood circulation.

If a drug is administered via the oral route, it must pass through gut wall and then through the liver before reaching the systemic circulation and its site of action. Extensive hepatic first-pass metabolism in the liver is often encountered, and a fraction of the dose administered may be eliminated before reaching the systemic circulation.

Accordingly, the increased amount of drug dose and dosing frequency are required to maintain blood levels within the therapeutic range. This results in the severe gastric upset or damages on stomach.

More, for a cancer patient, the anticancer drugs given orally cause adverse effects because most antitumour agents are not selective, but are highly toxic for both cancer and normal cells.

In lymphatic absorption, drug molecules enter directly into systemic circulation by bypassing the liver. Thus, the overall blood levels of drugs which undergo significant metabolism in the liver can be significantly increased if they can be directed to the lymphatic fluid.

In general, the lymphatic system is not an important route for drug entry into the body except for highly lipophilic compound, such as dietary fat, cholesterol, and lipid soluble vitamins.

Here, in order to use the advantages of the lymphatic system as drug absorption route, we attempted to use emulsion as drug carrier systems to transport medical drug.

The oil emulsions are absorbed easily into lymphatic capillaries transported to regional lymph node.

As a result, the oil emulsion can be considered as drug carriers to the lymphatic system by oral administration as well as by injection into tissues.

Accordingly, an emulsion containing anticancer agent is available in chemotherapeutic drug dosage form for lymph node metastasis, which is most common in human cancer.

But, in the case of oral administration of the emulsion containing anticancer drug the most of anticancer drugs are released in the stomach. So, anticancer agents can not reach in the small intestine. Thus, in the case of oral administration, the chemotherapeutic effect of anticancer drug is limited only on the stomach cancer. (CRC : Critical Review in Therapeutic Drug Carrier Systems, vol. 2 No. 3, pp. 245, 1986)

(2) Description of the prior Art

As the conventional method for microencapsulating the liquid fatty material like oil emulsion, U.S. Pat. No. 3,008,083; 3,749,799; and 3,819,838 disclose a solidification method of the capsule material, gelatin, by rapidly lowering the temperature and subsequent dehydration. While methods such as those disclosed in the patent literature set forth above have achieved some significant commercial success, difficulties have

been sometimes been encountered in rapidly inducing solidification of the microencapsulating material.

British Pat. No. 2,086,835 provides a process for encapsulating oils using polysaccharide as material for bead matrix. However this method produces shape-rataing, substantially water insoluble micro-beads containing a number of thousand oil droplet in the bead matrix.

This process can not provide a microencapsulated emulsion which is individually microencapsulated oil droplet in the powdery state(diameter: leas than 5µm).

Japan Pat. So 59-228930 provides a process for encapsulating olive oil using sodium alginate as capsule material. In this method, the core and capsule materials flow down as double layers on the vertical cone vibrated supersonically and the microcopsule are received in hardening solution or dried to harden the capsule material.

This method presented in Japan Pat. So 59-228930 must require the very complexed apparatus for microencapsulation.

SUMMARY OF THE INVENTION

This invention provides the microencapsulation method of oil droplet containing drugs for oral administration. The microencapsulated emulsion obtained in this invention represses the drug release from the emulsion and protects the emulsion and drug from the strong acidic condition of gastric juice. The oil droplet and drugs dispersed in the oil droplet were released rapidly in the small intestine with the disintegration of capsule material.

That is, this present invention provides the drug carrier system for oral administration which improves the prior method using biodegradable and biocompatible natural polymer such as polysaccharide which has a metal chelating capacity.

This present invention specifically provide microencapsulation method of oil droplet containing drug for oral administration. The microencapsulated emulsion obtained in this invention can reduce the gastric upset or damages on the stomach and can minimize the degradation of drug caused by hepatic first-pass metabolism, by inducing lymphatic absorption.

Embodiments of the present invention will now be described as follows.

First of all, the drug is mixed with liquid oil by sonication for 5-30 seconds to disperse the drug homogeneously in the oil phase. The drug-dispersed oil phase to be incorporated into the microcapsule is added to the aqueous solution mixture(to be used as capsule material) of polysaccharide which has metal chelating capacity, biocompatible and water soluble polymer(to improve the physical property of capsule material), and emulsifying agents. The two phase system (oil/aqueous solution mixture) is subjected to the sonicaiton to produce an oil-in-water emulsion containing the drug-dispersed oil droplets in the 1-5µm range of diameter.

As soon as possible after formation of the emulsion, it is added to multivalent cation-containing solution to harden the capsule material.

Finally, the microencapsulated emulsion is freeze-dried to obtain a final product in powdery state which is the subject of this invention.

The polysaccharide which has a metal cheating capacity, in this invention, include sodium alginate, pectin, xanthomonas campestris (XCPS), and carboxymethylcellulose (CMC).

The alginic acid family of linear 1-4 linked glycuronans are the copolymers composed of ˜-D-mannopyranuronic acid (M) residue and α-L-gulupyranuronic acid (G) residues that are arranged in homopolymeric (GG and MM) and heteropolymeric (MG) sequences in varying proportions and distribution patterns. Alginic acid can be derived from algal or bacterial sources.

In the invention, sodium salt of alginic acid was used as microcapsule material. Sodium alginate is water-soluble and has a good biodegradability, and sodium alginate is widely used for food, cosmetics, medicine, and pharmaceutials, because it is biodegradable and biocompatible material without immunogenic effect.

The biocompatible polymers used as capsule material mixed with polysaccharide in this invention include polyamino acid, sodium salt of polyacrylic acid, polylatic acid hydroxypropyl methylcellulose, and collagen protein. These polymers are available in markets and are used for cosmetics, toothpaste, shampoo, painting, and adhesives. These polymers are water soluble and mixed with polysaccharide in aqueous solution homogeneously.

The desirable mixing ratio of polysaccharide and these polymers is from 100:0 to 20:80.

If the content of these polymer exceeds 80 wt% of solution mixture, the hardened capsule material can not be obtained.

The core material in the invention is a liquid oil which is used widely for food or pharmaceuticals. Some representative examples of such liquid oil include corn oil, peanut oil, coconut oil, caster oil, sesame oil, soy bean oil, perilla oil, sunflower oil, and walnut oil.

Any types of drug which is stable on the subjection of sonication can be incorporated to oil phase in this invention. For example, these drugs include steroid drugs, anticancer drug like 5-flurouracil and me-CCNN, antibiotic, and antiulcer drug like omeprazole. The amount of drugs to be incorporated into oil phase in this invention is a 1-40 wt% of the liquid oil. If the amount of drug is more than 40 wt%, the excess of drug may be extracted from liquid oil.

In this invention, the emulsifying agents are used in the process in order to prepare for the stable oil-in-water emulsion. These emulsifying agents should be nontoxic and nonimmunogenic substances. Some examples of emulsifying agents in the invention include, Tween 20, Tween 40, Tween 80, Bile salt, sodium cholate, a mixture of 80 wt% ethyleneglycol 1000 monocetylether and 20 wt% ethyleneglycol 400, and polyoxyethylenether. The amount of emulsifying agents used in this invention is 5-10 wt% of the total amount of case and capsule material. If the amount of emulsifying agents is less than 0.5 wt%, the emulsion can not be formed.

The amount of aqueous phase of capsule material is a 100-200 wt% of the total amounts of liquid oil and drugs.

Multivalent cation used in this invention include aluminium (Al^{+3}) ions, calcium (Ca^{+2}) ions, or magnesium (Mg^{+2}) ion.

The concentration of cation is 0.5-5 wt% range.

In this present invention, the inventors use emulsification, chelation, and freeze-drying for the preparation of microencapulated emulsion containing drugs for oral administration instead of temperature dropping and dehydration(disclosed in U.S. Pat. No. 3,608,083, U.S. Pat. No. 3,749,799, and U.S. Pat No. 3,810,838).

The invention disclosed in british Pat. No. 2,086,835 provides multiply compartmentalized micro-bead and the invention disclosed in Japan Pat. So 59-288930 provides the diversified microcapsules in their diameter (20-100μm size) using the special apparatus for sonication.

It is the advantage of this invention that the powdery microencapsulated emulsions with regular size can be obtained and no special equipment for microencapsulation is required.

The invention will now be further understood from the following non-limiting examples, wherein all percentages are given by weight.

Examples

Example 1

4 parts of 5-fluorouracil (anticancer drug) as a model drug was mixed with 20 parts of corn oil as a core material by sonication for 10 seconds to disperse the drug homogeneously in the oil phase.

The drug-dispersed oil phase to be incorporated into the microcapsule is added to 20 parts of the aqueous solution of 5% sodium alginate(Junsei chemical Co., Ltd. Japan) containing 2.5 parts of bile salt as an emulsifying agent (Sigma Co., Ltd. U.S.). The two phase system (oil/aqueous solution mixture) was subjected to the sonication to produce oil-in-water emulsion containing the drug-dispersed oil droplet in the 1-5 μm range of diameter. As soon as possible after formation of the emulsion, it was added to 100 parts of 2.5% aluminum sulfate [$Al_2(SO_4)_3$] aqueous solution to harden the capsule material (sodium alginate).

Finally, the microencapsulated emulsion is freeze-dried to obtain a final product in powdery state which is the subject of this invention.

Example 2

The process of Example 1 was repeated except that 2.5% sodium alginate aqueous solution was employed in place of 5% sodium alginate aqueous solution.

Example 3

The process of Example 1 was repeated except that 1% sodium alginate aqueous solution was employed in place of 5% sodium alginate aqueous solution.

Example 4

The process of Example 1 was repeated except that the aqueous solution mixture of 20 parts of 5% sodium alginate aqueous solution and 5 parts of 5% polyamino acid aqueous solution was employed in place of 5% sodium alginate aqueous solution.

Example 5 to 7

The process of Example 1 was repeated except that the aqueous solution mixtures of 20 parts of 5% sodium alginate aqueous solution and 5 parts of 5% hydroxypropyl methylcellulose(or polyacrylic acid, or collagen) aqueous solution were employed in place of 5% sodium alginate aqueous solution.

Example 8

The process of Example 1 was repeated except that sodium salicylate was employed as a model drug in place of 5-fluorouracil.

Example 9

The process of Example 1 was repeated except that omeprazole which degraded rapidly in the strong acidic condition of gastric juice was employed as a model drug in place of 5-fluorouracil.

In this case, the microencapsulated emulsion was obtained as a bead form (the aggregate of powdery microencapsulated emulsion) and the enteric-coated bead with hydroxypropyl methylcellulose phthalate as a capsule matetial for enteric coating was used as a drug carrier system for omeprazole.

Example 10 to 12

The process of Example 1 was repeated except that 5% pectin, CMC, and XCPS aqueous solution was employed in place of 5% sodium alginate aqueous solution.

Comparative example 1

The process of Example 1 was repeated except that water was employed in place of 5% sodium alginate aqueous solution.

Comparative example 2

The process of comparative Example 1 was repeated except that sodium salicylate was employed as a model drug in place of 5-fluorouracil.

In Table 1, the release pattern of drugs (5-fluorouracil and sodium salicylate) from the drug carrier system was presented.

The drug carrier systems using the microencapsulated emulsion or emulsion was prepared according to the process described in Examples 1, 8, 10, 11, 12, and Comparative Examples 1, 2. The drug release experiment was performed in artificial gastric juice (pH = 2) using dialysis bag.

Table 1. Drug release pattern in the strong acidic condition(pH=2) of artificial gastric juice.

Example No.	Amount of released drug (mg)	
	after 3 hours	after 24 hours
Example 1	2.01	9.50
Example 8	8.10	22.8
Example 10	3.52	12.42
Example 11	4.12	14.10
Example 12	3.77	12.94
Comp. example 1	13.5	50.3
Comp. example 2	30.5	100.1

The amount of drug released from the drug carrier system was measured at 3 and 24 hours time points.

The result shows that the amount of drug released from the microencapsulated emulsion during first 3 hours is much less than that from emulsion without capsule material(control) indicating that the drug carrier system in this invention can repress the drug release in the strong acidic condition of gastric juice.

In addition, it was confirmed by a microscope that the stability of the microencapsulated emulsions in the strong acidic condition of gastric juice was improved significantly in comparison with that of control.

That is, it was observed that the microencapsulated emulsion prepared according to example 1 stayed intact in artificial gastric juice during 24 hour, while the emulsion prepared according to Comparative Example 1 was disintegrated and aggregated during 30 minutes staying in artificial gastric juice.

Figure 1 shows the drug release pattern in the artificial gastric juice as a function of the concentration of capsule material. The release amount drug released from the drug carrier system decreases as the concentration of sodium alginate solution used as capsule material increases. This is other evidence that the drug release is hindered by the capsule wall of the microencapsulated emulsion.

Table 2. The stability of drug carrier system in the artificial gastric juice and the release pattern of omeprazole in the artificial intestinal fluid.

Amount of drug carrier system used in each experiment	100mg
Loading amount	20mg
Amount of Omeprazole after staying in the artificial gastric juice for 2 hours (37°C)	18.5mg
Amount of released Omeprazole in the artificial intestinal fluid within 10 minutes (37°C)	19mg

* All the experiments were performed according to the procedures presented in U.S.P.

In Table 2, the stability of Omeprazole in the drug carrier system and the release pattern of the Omeprazole from the drug carrier system were observed using the microencapsulated emulsion as a drug carrier system. The drug carrier system was prepared according to the process described in Example 9 and the model drug was Omeprazole which was degraded rapidly in the gastric juice. More then 90% of total loading amount of Omeprazole remained stable after the stay in the artificial gastric juice(37°C) for 2 hours.

This drug carrier system was disintegrated rapidly in the artificial intestinal fluid and more than 90% of Omeprazole in the drug carrier system was released within 10 minutes.

Thus the micorencapsulated emulsion in this invention can be used effectively as the drug carrier system for oral drug which is unstable in the gastric juice.

As is apparent from the above results, the present invention provides a controlled oral drug carrier system which minimizes the degradation of drug in the gastrointestinal tract and maximizes the absorption of drug in the small intestine.

Claims

1. A process for microencapsulation of oil droplet containing medical drug for oral administration, said process comprising the following steps:

   first, the drug is mixed with liquid oil by sonication for 5-30 seconds to disperse the drug homogeneously in the oil phase; the drug-dispersed oil phase to be incorporated into the microcapsule is added to the aqueous solution mixture(to be used as capsule material) of polysaccharide which has metal chelating capacity, the biocompatible and water-soluble polymer(to improve the physical property of capsule material) and emulsifying agents; the two phase system (oil/aqueous solution mixture) is subjected to the sonication to produce an oil-in-water emulsion containing the drug-dispersed oil droplets in the 1-5μm range of diameter;

   as soon as possible after formation of the emulsion it is added to multivalent cation-containing solution to harden the capsule material; and

   finally, the microencapsulated emulsion is freeze dried to obtain a final product in powdery state which is the subject of this invention.

2. The process as claimed in claim 1, wherein the aqueous solution mixture (to be used as capsule material) contains 20-100 weight % of polysaccharide in the aqueous solution mixture.

3. The process as claimed in claim 1, wherein the polysaccharide which has metal-chelating capacity comprises pectin, xanthomonas campestrix (XCPS), and carboxymethyl cellulose (CMC).

. . .

4. The process as claimed in claim 1, wherein the biocompatible and water-soluble polymer comprises hydroxypropyl methylcellulose, water-soluble polyamino acid, the sodium salt of polyacrylic acid and collagen.

5. The process as claimed in claim 1, wherein the oil phase comprises any edible oil such as corn oil, peanut oil, coconut oil, castor oil, sesame oil, soybean oil, perilla oil, sunflower oil and walnut oil.

6. The process as claimed in claim 1, wherein the emulsifying agent comprises any biocompatible emulsifying agent such as Tween 20, Tween 40, Tween 80, sodium cholate, bile salt, a mixture of 80 w/v% polyethylene glycol 1000 mono cetyl ether and 20 w/v% polyethylene glycol 400, and polyoxyethylene ether.

7. The process as claimed in claim 1, wherein the mutivalent cation comprises aluminum ion, calcium ion and magnesium ion.

8. The process as claimed in claim 1, wherein the drug comprises any type of drug which is stable on the subjection of sonication such as steroid drug, antibiotic, and antitumour drug, and antiulcer drug which degrades rapidly in strong acidic condition of gastric juice such as Omeprazole.

Patentansprüche

1. Verfahren zur Mikroverkapselung von Öltröpfchen, die eine arzneilich wirksame Substanz zu oralen Verabreichung enthalten, wobei besagtes Verfahren folgende Schritte umfaßt:
Der pharmazeutisch wirksame Bestandteil wird mittels Ultraschall 5-30 Sekunden mit flüssigem Öl gemischt, bis der Wirkstoff gleichmäßig in der öligen Phase verteilt ist; die zur Mikroverkapselung vorgesehene ölige Phase, die den dispergierten pharmazeutisch wirksamen Bestandteil enthält, wird mit der als Metall-Gelbildner fungierenden wäßrigen Polysaccharid-Lösung (die als Ausgangsmaterial für die Kapselherstellung verwendet werden soll), dem physiologisch unbedenklichen und wasserlöslichen Polymer (das die physikalischen Eigenschaften des für die Kapselherstellung verwendeten Materials verbessert) und den Emulgatoren vermischt; das Zweiphasensystem (Gemisch aus Öl und wäßriger Lösung) wird mit Ultraschall behandelt, wodurch eine Öl-in-Wasser-Emulsion entsteht, die die wirkstoffhaltigen Öltröpchen mit einem Durchmesser von 1 bis 5 µm enthält;
anschließend erfolgt möglichst bald nach der Herstellung der Emulsion das Eintauchen in eine multivalente, kationenhaltige Lösung zwecks Härtung des Kapselmaterials; und schließlich wird die verkapselte Emulsion gefriergetrocknet, um ein Endprodukt in Pulverform zu erhalten, das Gegenstand der vorliegenden Erfindung ist.

2. Verfahren nach Anspruch 1, bei dem das Gemisch aus wäßriger Lösung (das als Ausgangsstoff für die Kapselherstellung verwendet werden soll) 20 bis 100 Masseprozent Polysaccharide enthält.

3. Verfahren nach Anspruch 1, bei dem das Polysaccharid, das als Metall-Gelbildner fungiert, Pectin, Xanthomonas campestrix (XCPS) und Carboxymethylcellulose (CMC) einschließt.

4. Verfahren nach Anspruch 1, bei dem das physiologisch unbedenkliche und wasserlösliche Polymer Hydroxypropylcellulose, eine wasserlösliche Polyaminosäure, das Natriumsalz der Polyacrylsäure und Collagen einschließt.

5. Verfahren nach Anspruch 1, bei dem die ölige Phase ein Speiseöl wie zum Beispiel Maisöl, Erdnußöl, Kokosöl, Rizinusöl, Sesamöl, Sojabohnenöl, Perillaöl, Sonnenblumenöl oder Walnußöl einschließt.

6. Verfahren nach Anspruch 1, bei dem der Emulgator ein physiologisch unbedenkliches Emulgiermittel wie zum Beispiel Tween 20, Tween 40, Tween 80, cholsaures Natrium, Gallensalz, ein Gemisch aus 80 Massevolumenprozent Polyethylglycol-1000-Monoceytlether und 20 Massevolumenprozent Polyethylenglycol 400 und Polyoxyethylenether einschließt.

7. Verfahren nach Anspruch 1, bei dem das multivalente Kation ein Aluminiumion, ein Kalziumion und ein Magnesiumion einschließt.

8. Verfahren nach Anspruch 1, bei dem das Arzneimittel jede Art von Arzneimittel einschließt, die bei einer Ultraschallbehandlung stabil bleibt wie zum Beispiel Kortikosteoride, Antibiotika und Zytostatika sowie Ulkustherapeutika, die im stark sauren Milieu des Magensaftes rasch zerfallen wie zum Beispiel Omeprazol.

Revendications

1. Procédé pour la micro-encapsulation d'une gouttelette d'huile contenant un médicament pour administration par voie orale, selon lequel :

   on mélange d'abord le médicament avec une huile liquide par sonication pendant 5 à 30 secondes, afin de disperser de manière homogène le médicament dans la phase huileuse; la phase huileuse à médicament dispersé, destinée à être incorporée dans la microcapsule, est ajoutée dans le mélange en solution aqueuse (destiné à être employé comme matière de capsule) d'un polysaccharide ayant un pouvoir de chélation de métal, du polymère biocompatible et soluble dans l'eau (afin d'améliorer les propriétés physiques de la matière de capsule) et d'agents émulsifiants ; le système biphasique (mélange d'huile et de solution aqueuse) est soumis à la sonication pour produire une émulsion huile-dans-eau contenant des gouttelettes d'huile à médicament dispersé d'un diamètre dans la plage de 1 à 5 µm ;

   dès que possible, après la formation de l'émulsion, on ajoute une solution à cation polyvalent afin de durcir la matière de capsule ; et

   l'émulsion micro-encapsulée est finalement lyophilisée pour obtenir un produit final à l'état pulvérulent qui fait l'objet de la présente invention.

2. Procédé selon la revendication 1, dans lequel le mélange en solution aqueuse (destiné à être employé comme matière de capsule) contient de 20 à 100 % en poids de polysaccharide dans le mélange en solution aqueuse.

3. Procédé selon la revendication 1, dans lequel le polysaccharide ayant un pouvoir de chélation de métal, comprend de la pectine, xanthomonas campestris (XCPS) et de la carboxyméthyl cellulose (CMC).

4. Procédé selon la revendication 1, dans lequel le polymère biocompatible et soluble dans l'eau comprend de l'hydroxypropyl méthylcellulose, un polyamino acide soluble dans l'eau, le sel de sodium d'un poly(acide acrylique) et du collagène.

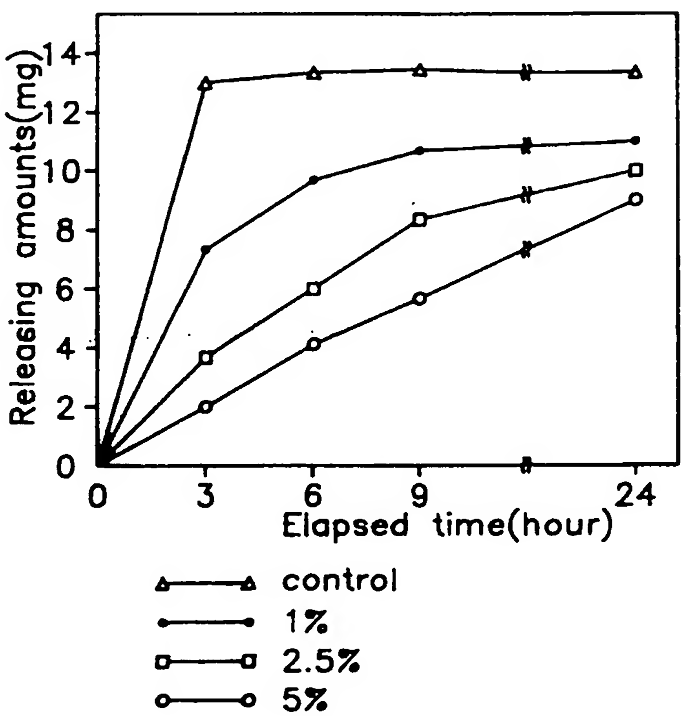
5. Procédé selon la revendication 1, dans lequel la phase huileuse comprend une quelconque huile comestible telle que l'huile de maïs, l'huile d'arachide, l'huile de coprah, l'huile de ricin, l'huile de sésame, l'huile de soja, l'huile de pérille, l'huile de tournesol et l'huile de noix.

6. Procédé selon la revendication 1, dans lequel l'agent émulsifiant comprend n'importe quel agent émulsifiant biocompatible tel que le Tween 20, le Tween 40, le Tween 80, le cholate de sodium, un sel biliaire, un mélange de 80 % enpoids d'éther de monocétyle et de polyéthylène glycol 1000 et de 20 % en poids de polyéthylène glycol 400, et l'éther de polyoxyéthylène.

7. Procédé selon la revendication 1, dans lequel le cation polyvalent comprend l'ion aluminium, l'ion calcium et l'ion magnésium.

8. Procédé selon la revendication 1, dans lequel le médicament comprend n'importe quel type de médicament stable lorsqu'il est soumis à une sonication tel qu'un médicament stéroïdien, un antibiotique, un médicament anti-tumoral et un médicament anti-ulcératif, qui se dégrade rapidement dans les conditions fortement acides du suc gastrique, tel que l'Oméprazole.

FIG. 1


Releasing amounts(mg)
0
2
4
6
8
10
12
14
0
3
6
9
24
Elapsed time(hour)
control
1%
2.5%
5%